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THE AQUATIC OLIGOCHAETA OF THE SANDUSKY RIVER, OHIO[1]

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Abstract. Aquatic oligochaeta were quantatively sampled from 10 stations on the Sandusky River between 26 October 1973 and 21 September 1974. Grab water samples were collected and analyzed for 15 parameters at the same stations. Eighteen species were collected with *Branchiura sowerbyi*, *Limnodrilus cervic*, *L. hoffmeisteri*, *L. spiralis*, *L. udekemianus* and *Tubifex tubifex* comprising 97.8% of the total identified fauna. Species composition and seasonal abundance differed in 3 distinct regions of the river, and the most oligochaetes/m^2 were collected in July and the least in May. Three sewage treatment plants seemed to have an impact on the number of species and mean number of individuals collected below their outfalls. Species diversity was determined at all stations and was significantly correlated ($P<0.5$) with 13 of the 15 physico-chemical parameters.

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Sandusky River arises at the confluence of Paramour Creek and Allen Run near Crestline, Ohio. The river is about 208.3 km long and has an average fall of about .73 m/km, thus dropping from an elevation of 333.1 m at its source to 174.7 m where it empties into the Sandusky Bay. The general characteristics of the river basin have been described by Baker (1975) and the geology summarized in detail by Forsyth (1975). A recent syposium (Baker *et al* 1975) considered land use, general water quality and biological water quality indexes within the basin. The aquatic oligochaete data presented in our paper are a result of an intensive benthic macroinvertebrate study from 26 October 1973 to 21 September 1974.

Although some aquatic oligochaetes are widely distributed, tubificids, especially, can attain high population densities when competition from other fauna is reduced, as in organically-polluted water (Brinkhurst and Jamieson 1971). Predation may play at least as great a role as competition in maintaining low populations in unpolluted areas. Intraspecific competition is a most important factor since the burrowing detritivore mode of life is uncommon (Howmiller 1977). Some species are able to withstand extended periods of negligible dissolved oxygen (Palmer 1970) and can therefore be ideal organisms for monitoring extreme conditions found in specific reaches of the Sandusky River.

MATERIALS AND METHODS

Ten sampling stations were designated on the Sandusky River and numbered in kilometers from the mouth of the river (figure 1 and table 1). These stations were selected to represent the habitat for a particular segment of river and to correspond to sites located above and below municipal sewage waste outfalls. Whenever possible, sites with automatic stream gauges were utilized. Using the stratified randon sampling technique, samples were collected during the second or third week of each month and between 26 October 1973 and 21 September 1974. No samples were collected in December because of high water.

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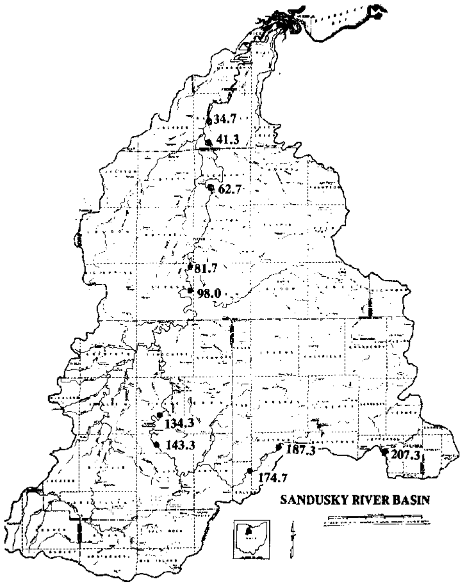

FIGURE 1. Location and number (in kilometers from the mouth) of sampling stations on the Sandusky River.

Grab water samples were also collected and analyzed for dissolved oxygen, temperature, pH, suspended solids, specific conductance, hardness, copper, iron, manganese, potassium, silica, sodium, ammonia, nitrate/nitrite, phosphate, and chlorophyll a. In retrospect, some parameters that would have more directly measured organic pollution (BOD, etc.) also should have been conducted.

The sampling apparatus used was the "BOP" (Prater *et al* 1977), and the sampling techniques used where those of Olive and Smith 1975). The samples were picked and sorted, and specimens were carefully classified and enumerated.

RESULTS AND DISCUSSION

Eighteen species of aquatic oligochaetes were collected: *Nais bretscheri* Michaelsen, *N. elinguis* Müller, *Dero digitata* (Müller), *Paranais frici* Hrabe, *Ophidonais serpentina* (Müller), *Aulodrilus pluriseta* (Piquet), *Branchiura sowerbyi* Beddard, *Ilyodrilus templetoni* (Southern), *Limnodrilus cervix* Brinkhurst, *L. claparedianus* Ratzel, *L. hoffmeisteri* Claparéde, *L. spiralis* (Eisen), *L. udekemianus* (Claparéde). *Peloscolex multisetosus longidentus* (Smith), *Potamothrix bavaricus* (Öschmann), *P. vejdovskyi* (Hrabe), *Tubifex tubifex* (Müller), and *Haplotaxis* cf. *gorioides* (Hartmann). The 6 dominant species, *Branchiura sowerbyi*, *Limnodrilus cervix*, *Limnodrilus hoffmeisteri*, *Limnodrilus spiralis*, *Limnodnodrilus udekemianus* and *Tubifex tubifex*, comprised 97.8% of the total indentified fauna.

With the exception of *L. udekemianus*, none of the immature stages of the species of *Limnodrilus* could be identified, due to their similarity. *T. tubifex* and *Ilyodrilus*

TABLE 1

Specific locale of stations on the Sandusky River for aquatic oligochaeta collected 26 October 1973–21 September 1974.

Station	Location
34.7	At km 34.7, Tindall Bridge (on Rice Road) 1.8 mi E of Havens, 3.5 mi SW of Fremont; Sect: 17, Twp: T4N, R15E, Ballville, Sandusky County.
41.3	At km 41.3, Darr South Road Bridge, (=Gilmore Bridge), 4.8 mi E of Burgon, 6.2 mi SSW of Fremont; Sect: 32, Twp: T4N, R15E,Ballville,SanduskyCounty.
62.7	At km 62.7, Co. Rt. 38 bridge, 2.9 mi S of Fort Seneca, 3.8 mi N of Tiffin; Sect.: 5/32, Twp: T23N, R15E, Clinton/Pleasant, Seneca County.
81.7	At km 81.7, Co. Rt. 90 bridge, 6.6 mi E of New Riegel, 5.8 mi S of Tiffin; Sect: 13, Twp: T1N, R14E, Seneca, Seneca County.
98.0	At km 98.0, Mexico Road bridge, 0.7 mi W of Mexico, 3.2 mi NW of Sycamore, Sect: 1, Twp: T1S, R14E, Tymochtee, Wyandot County.
134.3	At km 134.3, Co. Rt. 121 bridge, 0.9 mi S of Indian Mill, 2.1 mi NE of Upper Sandusky; Sect: 21, Twp: T2S, R14E, Crane, Wyandot County.
143.3	At km 143.3, bridge at S edge of Upper Sandusky, 5.5 mi NNW of Harpster: Sect: 5, Twp: T3S, R14E, Crane, Wyandot County.
174.7	At km 174.7, Caldwell Road bridge, 4.4 mi NW of Monnett, 7.6 mi SW of Bucyrus; Sect: 25/36, Twp: T3S, R15E, Dallas, Crawford County.
187.3	At km 187.3, Kestetter Road bridge, 1.6 mi W of center of Bucyrus, 5.7 mi SSE of Spore; Sect: 10, Twp: T3S, R16E, Bucyrus, Crawford County.
207.3	At km 207.3, Lowere Leesville Road (=Twp. Rt. 13) bridge, 1.1 mi W of Leesville, 2.5 mi E of North Robinson; Sect: 12, Twp: T16N, R21W, Jefferson, Crawford County.

templetoni have immature stages that are almost identical, and no attempt was made to identify further the immature tubificids with hair setae from the lower reaches of the river. Upstream from station 134.3, the only mature tubificid species with hair setae was *T. tubifex*, and it was assumed that all immature specimens with hair setae from this region of the river were of that species. One specimen of *Haplotaxis* sp. was collected from station 34.7. This was an immature individual, probably of *H. gorioides* (Hartmann).

DISTRIBUTION BY STATION

Based on the oligochaete species data, there were 3 distinct regions of the river. The lower part of the river (downstream from station 98.0) contained 10 tubificid species and a total of 14 species of oliogochaetes. This region, dominated by *B. sowerbyi*, *L. udekemianus*, and *L. hoffmeisteri*, contained the majority of those species characterized by intolerance to gross organic pollution. Among these species were *Haplotaxis* sp., most of the Naididae, and *Potamothrix vejdovskyi*.

From station 98.0 to station 143.3, there appeared to be a transition zone toward the more tolerant species. The more sensitive species were present in decreasing numbers, and the more tolerant ones were encountered in increasing numbers. In this region, the greatest diversity of oligochaete species occurred. *Branchiura sowerbyi*, *L. cervix*, and *L. hoffmeisteri* were the most abundant, while *L. spiralis* and *T. tubifex* were present in increasing numbers in upstream progression.

Upstream from station 143.3 in the most organically polluted portion of the river, 5 species totally dominated the oligochaete fauna. These consisted of *L. hoffmeisteri*, *L. cervix*, *L. spiralis*, *L. udekemianus*, and *T. tubifex*. Three additional species were present but they accounted for only 5 specimens.

The total number of oligochaetes also illustrated the river as 3 regions. The lower 4 stations were generally erratic in the number of oligochaetes present, the intermediate stations had an increasing number, and the upstream stations (174.3 through 207.3) contained an average of as many as 462 per square meter.

The relative numbers of individual species among stations was particularly interesting. *Branchiura sowerbyi* was among the most abundant of the tubificids at the lower and intermediate stations but was absent at stations 174.3, 187.3 and 207.3. Carroll and Dorris (1972) noted that *B. sowerbyi* was not particularly abundant in areas of oxygen deficit caused by organic pollution. Wurtz and Dolan (1960) found *B. sowerbyi* only at areas with low organic pollution. Aston (1973), however, mentioned that *B. sowerbyi* was tolerant of severe organic pollution in the tropics. In the Sandusky River, *B. sowerbyi* was abundant in areas with moderate amounts of organic input but was absent in stressed locations.

The abundance of *L. spiralis* and *T. tubifex* was the inverse of *B. sowerbyi*. With the exception of a single specimen of *T. tubifex* collected from station 41.3, all representatives of these 2 species were present in samples collected from the areas of greatest organic loading. Both reached their greatest abundance at station 187.3, and decreased in abundance at the less polluted locality at station 207.3.

Limnodrilus cervix and *L. udekemianus* were widespread in their distribution in the Sandusky River. Both were collected at 9 of the 10 stations. *Limnodrilus udekemianus* was notable in its general constancy in the number of individuals collected throughout the length of the river: the influence of organic loading appeared to neither stimulate nor suppress the population numbers. *Limnodrilus cerix*, conversely, appeared to be adversely affected by the extreme conditions at station 187.3. The great abundance of *L. cervix* at station 207.3, however, is unexplained; the numbers of mature specimens of this species collected were greater than the numbers of all other mature individuals combined. *Limnodrilus hoffmeisteri* was the most widespread and the most abundant tubificid in the river. It was consistently among the most common of the oligochaetes at all stations. Its well-known tolerance to stress conditions (Brinkhurst 1962) was demonstrated by its abundance at station 187.3.

The Naididae, with the exception of one specimen of *Nais bretscheri* collected from station 174.3, were restricted to the lower and intermediate regions of the river. The numbers of specimens collected were too small to allow any conclusions concerning the distribution of the various species.

SEASONAL DISTRIBUTION

The small number of identifiable oligochaetes collected restricted analysis of the temporal abundance to the more common species. The seasonal abundance was found to vary between the regions of the river with the more organically enriched areas at the upper end of the river (stations 174.3 through 207.3) contained not only more oligochaetes than the more downstream stations. Except for two species, *L. hoffmeisteri* and *L. cervix*, the numbers of mature specimens were considerably more erratic. Studies of the life histories of tubificids (Kennedy 1966a, 1966b; Carroll and Dorris 1972) have revealed that breeding cycles vary according to the productivity of the habitat. This variable undoubtedly had some influence on the differences between the regions.

At the upstream end of the river, mature *L. hoffmeisteri* were abundant from November to July, with peaks in abundance in January, April and July. There was a decrease in abundance in August, and in September none were collected. The decrease in August and the absence in September may have been due to the decreased stream flow concentrating the material from the sewage treatment plants, and the resultant low levels of dissolved oxygen. At the downstream stations (34.7 through 134.3), mature *L. Hoffmeisteri* were not as abundant as at the upper end of the river, although the combined station data show that the species was collected each month. Peaks in abundance were recorded in January, March and June, indicating that this species was generally more abundant in the winter months in upolluted waters.

Although the numbers of *L. cervix* collected from the upstream stations were quite variable, peaks were present in April, July and September. Among the downstream stations, this species was collected infrequently and was often absent as mature individuals, but an increase in abundance was found during the late summer.

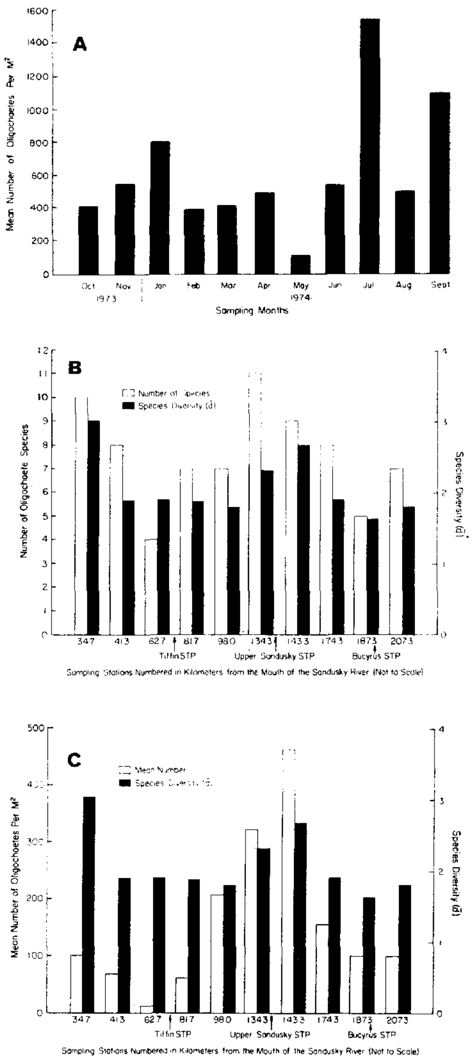

FIGURE 2. (A) Mean number of aquatic oligochaetes/m² per month at all stations, 26 October 1973–21 September 1974.

(B) Total number of aquatic oligochaetes species and species diversity index (d̄) per station, 26 October 1973–21 September 1974.

(C) Number of aquatic oligochaetes/m² and species diversity index (d̄) per station, 26 October 1973–21 September 1974.

The temporal abundance of *L. spiralis* is based on combined data from stations 134.3 through 207.3. Peaks occurred in January, March and June. As with *L. hoffmeisteri*, the majority of the specimens was collected from station 187.3. The absence of individuals from samples taken in summer may have been due to the same factors that presumably affected *L. hoffmeisteri*.

Tubifex tubifex did not present a picture of seasonal abundance which could be interpreted. This species was erratic in samples even from the same location. Mature individuals were collected in large numbers in July and September, but neither mature nor immature individuals were present in August samples.

Branchiura sowerbyi was found by Carroll and Dorris (1972) to be abundant from winter to late spring, and less common during summer and autumn. With the exception of January, this was also the case in the Sandusky River. Numbers decreased from March to May and gradually rose to a peak in abundance in September.

The mean numbers of aquatic oligochaetes/m²/month (fig. 2A) at all stations during the study interval supported the conclusion that even worms cannot tolerate organic pollution in excess, although they are called sludge worms. At the time of this study, the cities of Bucyrus, Upper Sandusky and Tiffin had inadequate sewage treatment plants. As the oligochaete fauna collected ranged from intolerant to tolerant, a moderate amount of enrichment favored both oligochaete

TABLE 3

Comparison of the mean number of Oligochaetes/m², number of Species, and Species Diversity indexes ($\bar{d}$) collected from Sandusky River, Ohio, 26 October 1973–21 September 1974.

Station	No. m²*	No. Species	$\bar{d}$
34.7	100	10	3.03
41.3	69	8	1.91
62.7	12	4	1.92
81.7	60	7	1.89
98.0	208	7	1.81
134.4	322	11	2.31
143.3	462	9	2.67
174.7	155	8	1.92
187.3	100	5	1.64
207.3	1000	7	1.82

*Mean number of oligochaetes/m².

TABLE 2

Mean chemical parameters in mg/ℓ for the study period 26 October 1973–21 September 1974.

	Stations									
	34.7	41.3	62.7	81.7	98.0	134.3	143.3	174.7	187.3	207.3
Temp. Air °C	12.06	12.41	12.36	11.40	15.10	14.36	14.00	14.27	14.09	15.41
Temp. Water °C	12.95	13.73	13.59	12.27	14.00	14.09	13.95	14.27	13.41	14.05
DO	8.2	6.8	8.6	9.4	9.0	9.9	9.2	9.3	7.3	8.4
pH	7.6	7.6	7.72	7.67	7.88	7.90	7.86	7.93	7.53	7.84
Sp. Cond.	596.5	740.0	751.00	721.67	817.00	716.00	698.20	678.80	722.28	705.50
Susp. Solids	110.72	41.68	23.5	42.15	76.64	39.80	50.43	35.83	20.85	19.05
Calcium	57.95	62.88	66.88	74.16	76.56	76.15	73.87	63.10	56.28	63.08
Magnesium	30.26	30.18	29.7	29.84	32.32	27.53	26.76	19.20	17.42	22.94
Copper	0.09	0.07	0.01	0.02	0.02	0.03	0.01	0.02	0.12	0.02
Fluoride*	—	0.68	—	—	—	—	—	—	—	—
Iron	0.86	1.28	0.79	1.10	1.45	0.32	0.88	1.53	2.02	0.97
Manganese	0.29	0.11	0.09	0.11	0.12	0.10	0.11	0.11	0.10	0.09
Potassium	5.76	5.46	5.10	4.58	5.14	6.33	4.85	6.42	8.36	6.26
Silica	2.92	2.92	2.73	5.73	6.57	5.43	5.46	6.11	7.37	9.35
Sodium	9.64	9.72	10.1	8.71	9.32	11.95	9.94	12.52	12.94	14.60
Ammonia	0.05	0.11	0.23	0.11	0.09	0.16	0.90	0.16	1.54	0.68
Nitrate/Nitrite	9.78	0.09	0.52	1.12	0.42	0.67	0.37	0.73	0.94	0.83
Total Nitrogen	—	—	1.7	0.83	—	1.74	—	5.3	—	3.0
Ortho PO_4	0.80	0.10	0.25	0.08	0.14	0.50	0.22	0.66	1.45	1.08
Total PO_4	0.37	0.07	0.40	0.21	0.62	0.61	0.42	1.02	1.43	1.74
Chlorophyll a	—	326	1002	232	426	592	827	305	167	130

*Only value.

species diversity and total number of species (fig. 2B) and the mean number of oligochaetes/m^2 to $\bar{d}$ values (fig. 2C). With the increased eutrophication and decrease in populations of less tolerant, competitive invertebrate forms (Prater, 1975), the habitats became more favorable for aquatic oligochaetes.

Dissolved oxygen did not appear to be a significant variable (correlation coefficient of −.1653); however, the correlation coefficient relationships of species diversity indexes and physicochemical parameters of suspended solids (.7053), nitrate/nitrite (.1792), water temperature (.3753), pH (.5784), iron (.5736), manganese (.7507), and chlorophyll a (.4301) illustrated significant correlations.

The Shannon-Weaver function for species diversity indexes ($\bar{d}$) using the Lloyd, Zar, and Karr formula (EPA-670/4-73-001, 1973) was utilized. The $\bar{d}$ values for our stations based on oligochaete data are illustrated in table 3, which also lists the station, mean number of oligochaetes/m^2, and the total species number collected at each station during the study period. The highest $\bar{d}$ (3.03) was at station 34.7. This station had the greatest number of species (10). The largest number of species (11) was collected at station 134.4 where the $\bar{d}$ was 2.31. The greatest mean number/m^2 (1000) was at station 207.3 where the $\bar{d}$ was 1.82 (second lowest) and the total species count was 7.

All of the species of Tubificidae are known to occur in at least mesotrophic conditions: *L. hoffmeisteri* and *T. tubifex* are the species most generally listed as being characteristic of severe organic pollution (Johnson and Brinkhurst 1971, Aston 1973). The tolerance to organic pollution of the species of other families is less well known, although Brinkhurst (1963) found *Nais elinguis* to be abundant in areas of organic loading, and Loden (1974) observed that *Dero digitata* was present in areas of low dissolved oxygen.

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